AD 410284

VARIAN ASSOCIATES - BOMAC DIVISION
Salem Road
Beverly, Massachusetts

BL-221 70 Gc MAGNETRON PRODUCTION ENGINEERING MEASURE

Fourth Quarterly Progress Report
6 May 1962 to 6 August 1962

CONTRACT NO: DA-36-039-SC-85974

CONTRACTING AGENCY: U. S. Army Signal Supply Agency
225 South Eighteenth Street
Philadelphia 3, Pennsylvania

ATTENTION: Contracting Officer
PEM and Facilities Procurement Branch
Procurement Management Division "C"

VARIAN ASSOCIATES - BOMAC DIVISION
Salem Road
Beverly, Massachusetts

BL-221 70 Gc MAGNETRON PRODUCTION ENGINEERING MEASURE

Fourth Quarterly Progress Report
6 May 1962 to 6 August 1962

OBJECT: To investigate minor constructional modifications in the present design, evaluate a pre-production run of thirty (30) tubes and set up manufacturing facilities capable of producing fifty (50) tubes per month.

CONTRACT NO: DA-36-039-SC-85974

SIGNAL CORPS REQUIREMENTS: SCS-70 dated 23 September 1959

Prepared by:

Gary G. Riska
Project Engineer, Power Tube
Product Development Group

Approved by:

Richard S. Briggs
Manager, Power Tube
Product Development Group

FOURTH QUARTERLY PROGRESS REPORT

TABLE OF CONTENTS

DRAWINGS AND GRAPHS

1. PURPOSE

The purpose of this PEM Program is to investigate minor constructional modifications in the present BL-221 magnetron design and to set up a manufacturing facility capable of producing at a rate of fifty (50) tubes per month.

Among the constructional design modifications to be undertaken will be:

a) Construction and evaluation of a BL-221 tube with a permanently attached Vac-Ion Pump.

b) Replacement of the present glass output window assembly with a ceramic or sapphire structure.

Four (4) model tubes incorporating the design modifications adopted are to be delivered to the Signal Corps for evaluation purposes and thirty (30) additional tubes are to be manufactured after approval by the Contracting Agency.

2. ABSTRACT

Along with the development of a broadband ceramic output window structure other activities initiated and/or pursued during this quarterly period were as follows:

a) Preparation and submittal of a special report under date of 27 May 1962 dealing specifically with the Vac-Ion Pump Appendage investigation;

b) Initiation of a design study program to determine the feasibility of making the BL-221 magnetron frequency tunable;

c) Initiation of a study on rust and corrosion of external tube parts and effect of such corrosion on internal tube pressure or vacua;

d) Completion of the anode hobbing facility set-up for development quantities;

e) Continuation of effort to resolve the overheating problems in the new test equipment.

3. FACTUAL DATA

3.1 Vac-Ion Pump Appendage Investigation: No additional data on this investigation was compiled during this quarterly period. The results of this study as listed in the previous quarterly reports and as further assessed and analyzed in a special report under date 27 May 1962 were considered as adequate. Bomac, therefore, in compliance with the SELMA-M5f-7 (JJ) communication under date 20 August 1962, will defer the incorporation of the Vac-Ion Pump Appendage in the present tube design during this PEM Program.

3.2 Ceramic Output Window Assembly Investigation: A second tube (tube #3) representing the original design approach (refer to the previous quarterly progress reports for experimental results and constructional details) was constructed and evaluated during this quarterly interval. As was the case with the first tube built and evaluated (tube #2, Third Quarterly Report) the single point resonant window approach while desirable from a theoretical point of view because of its unique characteristics to suppress

3.2 Continued

interference from adjacent modes, failed again to yield the predicted results in a finished or completed tube. Inability or the difficulty again to make the resonant frequencies of the window structure and anode resonators coincide caused this tube to yield very little power output - three or so kw.

A program to design and develop a broadband ceramic window assembly was launched at this time. Several window assemblies built and evaluated under this approach were found very successful indeed. Design and constructional details of this window assembly, referred to in this report as Model #2, are shown in the drawings on pages 17 and 18. A comparison of this ceramic window assembly with the original design and a typical glass window structure in terms of low level or cold electrical characteristics is presented in the graph on page 19. Initial operational test data as compiled on three (3) tubes (tubes #4, #5, and #6) built with the new ceramic window assembly are tabulated on the following pages 5, 6, and 7. On page 20 the frequency vs. VSWR in db representing tube No. 4 is presented.

BL-221
TEST DATA

TUBE NO. 4

TEST DATE	TESTS	Heater Conditions				Input Conditions			Output			Pulse Conditions				Internal Tube Pressure (mmHg)	Life Cycle
		Starting		Operating													
		Eh (V)	Ih (A)	Eh (V)	Ih (A)	ib (A)	Ib (Ma)	epy (kv)	Po (W)	po (kw)	Fo (Gc)	tp (μsecs)	prf (pps)	du	Type Pulser		
6/12/62	Osc. 1	6.3	2.6	3.1	1.5	9.0	2.7	12.35	2.95	14.80	69.95	0.02	10,000	0.0002	HTM	1×10^{-8}	
	Osc. 2	6.3	2.6	2.72	1.3	9.0	4.5	12.35	7.40	14.80	69.95	0.06	8,340	0.0005	HTM	1×10^{-8}	
	Osc. 3	6.3	2.6	2.72	1.3	9.0	4.5	12.35	7.40	14.80	69.95	0.30	1,670	0.0005	HTM	1×10^{-8}	
6/19/62	Osc. 1	6.3	2.6	3.1	1.5	9.0	2.8	12.90	3.04	15.20	69.95	0.02	10,000	0.0002	HTM	1×10^{-8}	
	Osc. 2	6.3	2.6	2.72	1.3	9.0	4.5	12.90	7.60	15.20	69.95	0.06	8,340	0.0005	HTM	1×10^{-8}	
	Osc. 3	6.3	2.6	2.72	1.3	9.0	4.5	12.90	7.60	15.20	69.95	0.30	1,670	0.0005	HTM	1×10^{-8}	
		Following the above tests the split exhaust magnets were removed, Vac-Ion Pump was pinched off and tube was permanently packaged and regaussed, etc.															
6/21/62	Osc. 1	6.3	2.6	3.10	1.5	9.0	2.7	13.25	2.6	13.0	70.13	0.02	10,000	0.0002	HTM		
	Osc. 2	6.3	2.6	2.72	1.3	9.0	4.5	13.25	6.5	13.0	70.13	0.06	8,340	0.0005	HTM		
	Osc. 3	6.3	2.6	2.72	1.3	9.0	4.5	13.25	6.5	13.0	70.13	0.30	1,670	0.0005	HTM		
	NOTE:	Following the 21 June testing tube was placed in storage. Subsequent to this storage period tube is scheduled for operational life test evaluation.															

BL-221
TEST DATA

TUBE NO. 5

TEST DATE	TESTS	Heater Conditions				Input Conditions			Output			Pulse Conditions				Internal Tube Pressure (mmHg)	Life Cycle
		Starting		Operating													
		Eh (V)	Ih (A)	Eh (V)	Ih (A)	ib (A)	Ib (Ma)	epy (kv)	Po (W)	po (kw)	Fo (Gc)	tp (secs)	prf (pps)	du	Type Pulser		
6/19/62	Osc. 1	6.3	2.55	3.10	1.48	9.0	2.7	12.7	3.2	16.0	70.4	0.02	10,000	0.0002	HTM	1×10^{-8}	- - -
	Osc. 2	6.3	2.55	2.72	1.28	9.0	4.5	12.7	8.0	16.0	70.4	0.06	8,340	0.0005	HTM	1×10^{-8}	- - -
	Osc. 3	6.3	2.55	2.72	1.28	9.0	4.5	12.7	8.0	16.0	70.4	0.30	1,670	0.0005	HTM	1×10^{-8}	- - -
6/25/62	Osc. 1	6.3	2.55	3.10	1.48	9.0	2.7	13.3*	2.3*	11.5*	70.4	0.02	10,000	0.0002	HTM	1×10^{-8}	- - -
	Osc. 2	6.3	2.55	2.72	1.28	9.0	4.5	13.3*	6.4*	13.8*	70.4	0.06	8,340	0.0005	HTM	1×10^{-8}	- - -
	Osc. 3	6.3	2.55	2.72	1.28	9.0	4.5	13.3*	6.4*	13.8*	70.4	0.30	1,670	0.0005	HTM	1×10^{-8}	- - -
		Following the above tests, the split exhaust magnets were removed from the tube, the Vac-Ion Pump system was pinched off, and the tube was permanently packaged and regaussed, etc.															
7/23/62	Osc. 2	6.3	2.55	2.72	1.28	9.0	4.5	14.25*	4.3*	9.6*	70.4	0.06	8,340	0.0005	HTM	- - -	- - -

NOTES: * The power slump and the increase in the peak anode voltage in this tube were attributed to cathode poisoning suspected to have occurred during the long pulse (0.30 secs) aging in the hard tube modulator where arcing between anode and cathode was experienced.

BL-221

TEST DATA

TUBE NO. 6

TEST DATE	TESTS	Heater Conditions				Input Conditions			Output			Pulse Conditions				Internal Tube Pressure (mmHg)	Life Cycle
		Starting		Operating													
		Eh (V)	Ih (A)	Eh (V)	Ih (A)	ib (A)	Ib (Ma)	epy (kv)	Po (W)	po (kw)	Fo (Gc)	tp (μsecs)	prf (pps)	du	Type Pulser		
7/5/63	Osc. 1	6.3	2.6	2.42	1.15	9.0	2.8	13.4	3.0	15.0	70.2	0.02	10,000	0.0002	HTM	1×10^{-8}	
	Osc. 2	6.3	2.6	2.12	1.10	9.0	4.5	13.4	7.5	15.0	70.2	0.062	8,100	0.0005	HTM	1×10^{-8}	
	Osc. 3	6.3	2.6	2.12	1.10	9.0	4.5	13.4	7.5	15.0	70.2	0.30	1,670	0.0005	HTM	1×10^{-8}	
		Following the above tests the split exhaust magnets were removed from the tube, the Vac-Ion Pump system was pinched off and the tube was permanently packaged and regaussed, etc.															
7/13/62	Osc. 1	6.3	2.6	2.42	1.15	9.0	2.8	13.25	2.8	14.0	70.2	0.020	10,000	0.0002	HTM		
	Osc. 2	6.3	2.6	2.12	1.10	9.0	4.5	13.25	7.0	14.0	70.2	0.062	8,100	0.0005	HTM		
	Osc. 3	This test was not performed due to need of equipment repair.															
	NOTE:	Following the 13 July 1962 tests tube was placed in storage. Subsequent to this storage period tube is scheduled for operational life test evaluation.															

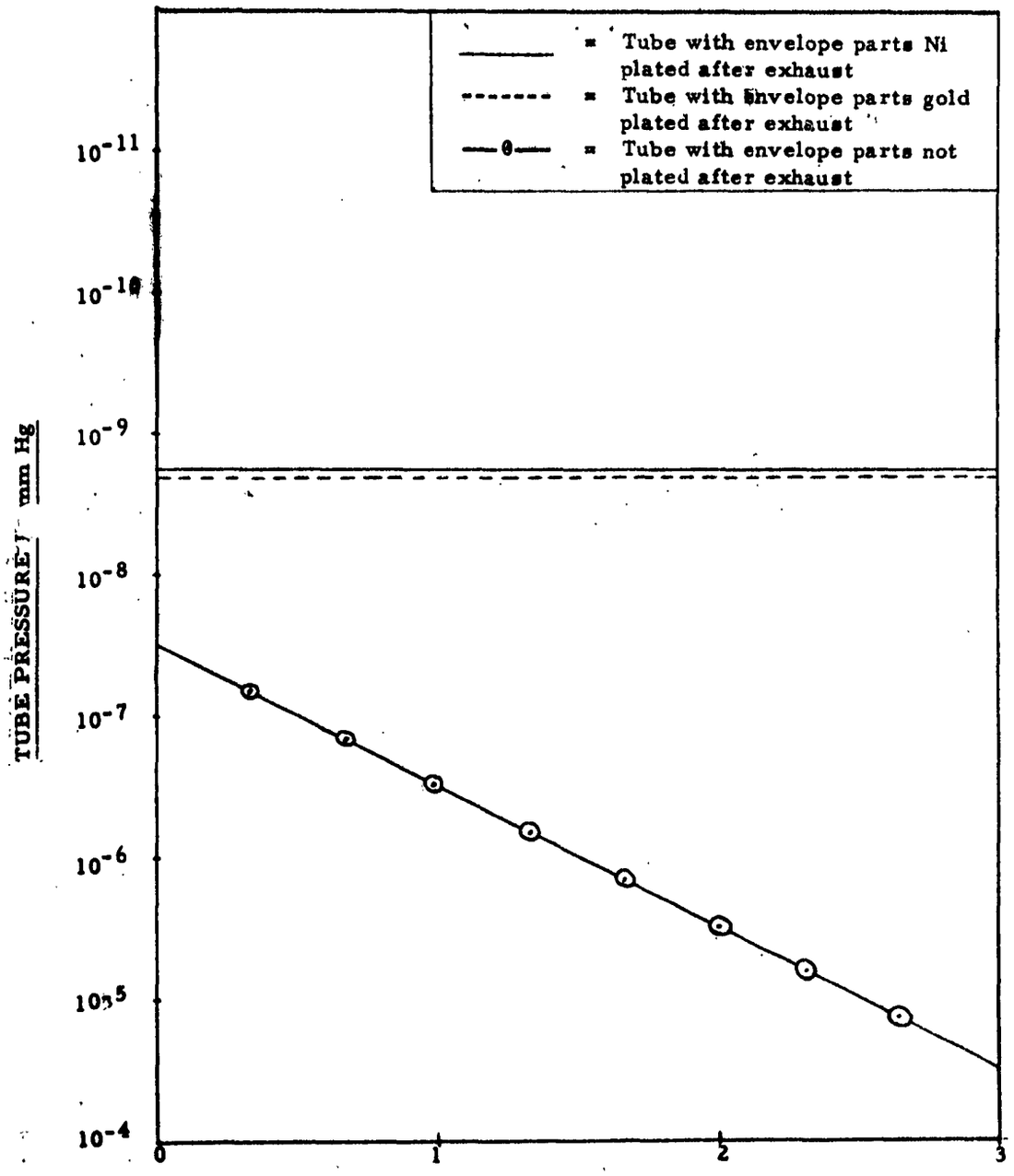
3.3 Humidity - Temperature Investigation of Exposed or Tube Envelope Parts: In order to test effects of humidity and temperature on the tube envelope during long storage periods and effect of any corrosion on internal tube pressure and therefore general tube performance, three (3) tubes, one (1) with the exposed parts as originally processed, one (1) with the exposed parts gold plated and a third with the same parts nickel-plated were subjected to a storage test at a controlled relative humidity of 100% and a temperature of 100°F. Nickel and gold-plating was done following the pumping or tube exhaust process.

The results obtained over a three (3) month period are plotted on page 9.

Although the initial pressure on the tube with no plating following the exhaust operation was higher than the two plated tubes the continuous increase of pressure on this tube with time was attributed to hydrogen diffusion or permeation through the exposed metal tube parts. Factors enabling one to reach this conclusion may be listed as follows: a) No change in pressure took place in this tube during the several weeks storage period under normal humidity temperature conditions prior to the commencement of the humidity chamger test; b) the ionized gas color in this tube was not that characteristic of air; c) the steel

BL-221

HUMIDITY CHAMBER TESTS



3.3 Continued

exposed envelope parts showed a considerable amount of rust/or corrosion and, c) no rust or corrosion was detected in the gold and nickel plated tubes.

Reference is made to a paper delivered to the Sixth National Conference on Tube Techniques by Louis R. Falce of Varian Associates, Inc. This paper entitled, Some Techniques of Design and Construction of Metal Envelope Vacuum Tubes for Severe Environments, describes the electrolytic phenomenon that occurs when iron or steel (also kovar) is exposed to water containing oxygen or moist air. In its simplest description, iron (F_e) in the presence of hydrogen ions formed by hydrolysis of water or moisture forms iron ions (F_e ++) plus 2 nascent (2H) atoms of hydrogen. The latter readily permeate the iron envelope particularly at higher temperatures. After entering the inner vacuum space, the nascent hydrogen atoms combine to form hydrogen gas molecules. As this action is continued, the inner vacuum space builds up a pressure of hydrogen gas. In the meantime the Fe++ ions on the outer envelope combine with oxygen from the water to form rust (F_e 2 0_3).
In order to prevent the above corrosion and hydrogen permeation, the iron surfaces may be plated or coated with suitable materials.

3.4 Tuner Investigation: Two exploratory designs were considered under this investigation to determine whether the BL-221 magnetron could be made frequency tunable. The first of these utilized a bellows mechanism which would permit the travel of a washer type segment over two or more of the large anode resonators 180° away from the output cavity and in a direction perpendicular to the major tube axis. See drawing on page 21 for constructional details.

The second design made use of a similar bellows system differing from the first approach in the following aspects: a) The tuner system is located at the exhaust end of the tube instead of at the side of the anode; b) in this design a full washer or ring is utilized instead of a small segment inductively tuning all the large anode resonators instead of two. Note drawing on page 22 for a detailed presentation of this tuner design or structure.

Preliminary tests with the first tuning model conducted on a conventional type low level or cold test set-up involving only the anode and output transformer assembly indicated tuning of a few megacycles but far less than desired.

Because of the inadequacy of this design, work on the second model

3.4 Continued

was initiated. Since however the design changes in the tube turned out to be of a major developmental nature and since the know how in the manufacturing of anodes for millimeter magnetrons had progressed to a point whereby meeting the specified frequency requirements (69.0 - 70.5 Gc) was no longer a problem, the program for the development of this tuning system was discontinued during this interval.

3.5 Anode Hobbing Facility: The last items on order as listed in the previous quarterly progress report were received in early July 1962. With the arrival of these items at Bomac, namely the Hob Holding Dies Item 506, and Hob Grinder - Item 507 the installation phase of this facility was completed. Grinding of hobs and evaluation of anodes produced at Bomac with this facility are scheduled to take place sometime during the forthcoming quarterly period.

3.6 Soft Tube Modulators - Items 401, II and 404, V: The problems of malfunction in these modulators due to overheating of the pulse transformer at the 14,000 - 20,000 pps repetition frequency conditions (du = .0005, tp = 0.03±0.005μsec's) continued unresolved. The new transformer designed around a duty ratio of 0.0015 or three times the

3.6 Continued

value of the original units referred to in the last quarterly report also proved inadequate for the task. Bomac is currently consulting with new vendors concerning this problem. One of these transformer suppliers, the Aircraft Marine Products, Inc., Elizabethtown, Pa., has promised the construction and delivery of two (2) units sometime in late August or early September 1962.

4. CONCLUSIONS

4.1 Vac-Ion Pump Appendage Investigation: Although inconclusive, Vac-Ion pump appendages do not appear to offer any improvement. Bomac has recommended in a special report of 27 May 1962 that this work be terminated on the current contract.

4.2 Ceramic Output Window Investigation: A satisfactory broadband ceramic window has been designed and evaluated, and will be incorporated in future tubes. This makes a substantial improvement in the tube from the point of view of load sensitivity, average power output capability and better resistance to thermal shock.

4.3 Humidity - Temperature Investigation: Storage corrosion problems have been resolved by nickel or gold plating techniques up to 100% humidity and 100°F conditions.

4. Continued

4.4 Tuner Investigation: Tuner investigation shows that tunability in the present tube is possible. The improved control of basic anode dimensions has made tunability unnecessary in order to stay within the frequency band requirements. Development of a production model with at least 2 Gc tunability appears possible at some future time.

4.5 Anode Hobbing Facility: Although approximately seven (7) months behind schedule due to procurement and/or delivery difficulties experienced with certain components, this facility is now in an operational status. Sample tubes built with anodes manufactured in this facility are scheduled for evaluation during the next quarterly period.

4.6 Test Equipment Facility: With the exception of the difficulties experienced in the procurement of pulse transformers affecting in particular the short pulse life test conditions the test equipment facility is in a state of readiness.

5.0 PROGRAM FOR THE NEXT QUARTERLY PERIOD

5.1 Operational life test evaluation of tubes built with the ceramic output window assembly.

5.2 Manufacturing of one or more anode hobs in the new hobbing installation or facility.

5.0 Continued

5.3 Evaluation of anodes manufactured in the anode facility.

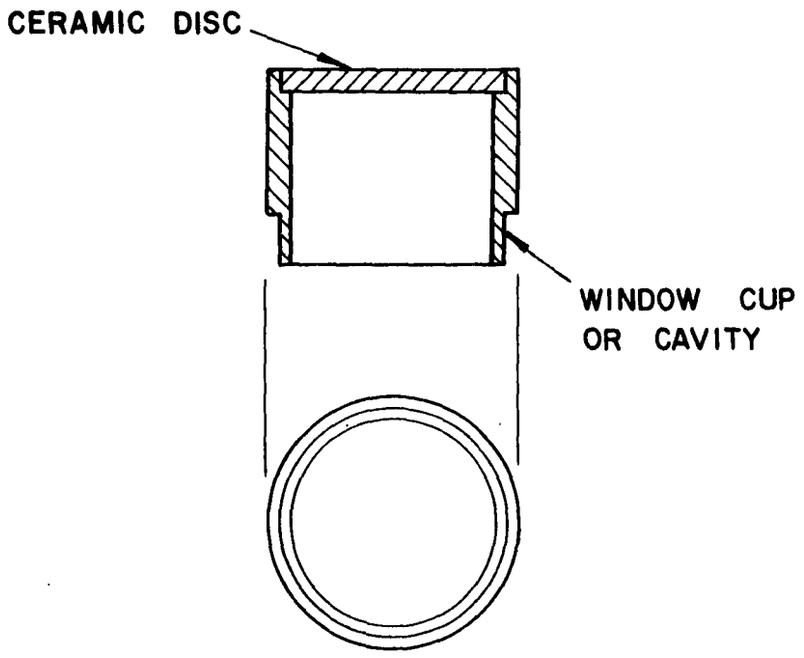
5.4 Follow through in the procurement and search for pulse transformers suitable for high pulse repetition frequency (20,000 pps) work in the soft tube modulator equipment.

5.5 Re-assessment of the short pulse or high pulse repetition frequency test conditions with the Signal Corps in view of the difficulties encountered in the procurement of suitable high pulse repetition frequency pulse transformers.

5.6 Investigation for possible improvement of the present cathode centering system.

MAN HOURS OF WORK PERFORMED

		Hours
1.	Richard S. Briggs, Manager	31.00
2.	Herbert H. Chun, Assistant Manager	195.00
3.	Gary G. Riska, Project Engineer	201.00
4.	Alan P. Waterman, Test Equipment Design/Construction	12.00
5.	Miscellaneous:	
	This category includes all other man hours expended on the program in such areas as testing, processing, assembly work, drafting, incoming material inspection, test equipment construction work, inspection installation and trial run of anode hobbing facility equipment received, etc.	777.75
	Total Time Expended	1,216.75 hrs.

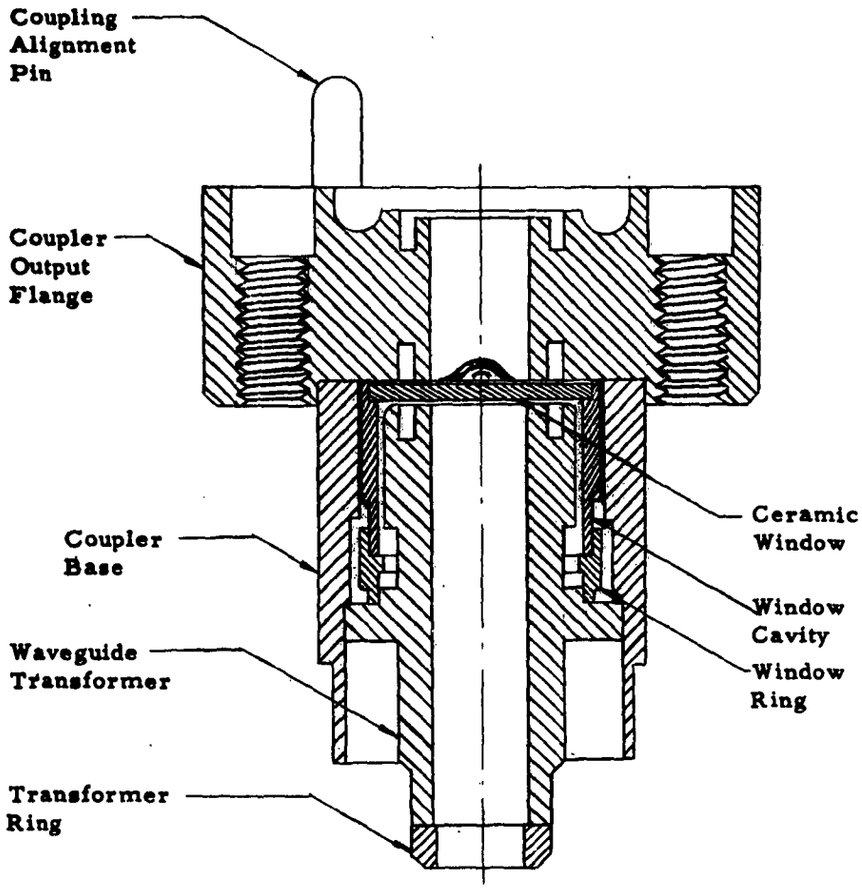


NOTE

MOLY-MANGANESE SEALING OR JOINING COMPOUND USED.

TENTATIVE	SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
MODEL NO.2	CERAMIC DISC-CUP ASSEMBLY	4/17/62

W-101

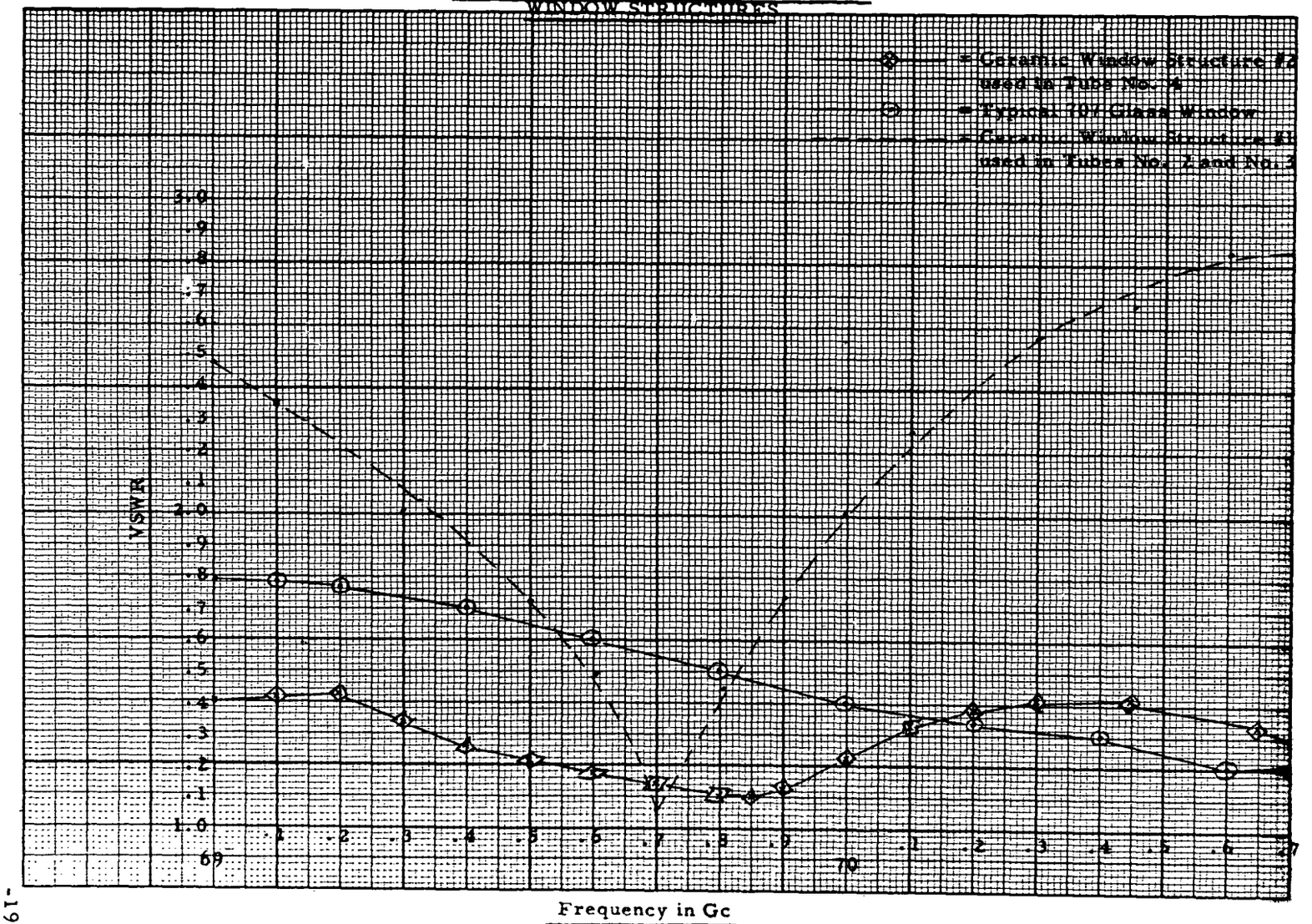


TENTATIVE	**SPECIFICATION SHEET**	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
Model No. 2	Ceramic Output Window Assembly	4/17/62

NO. 340R-20 DIETZGEN GRAPH PAPER
20 X 20 PER INCH

EUGENE DIETZGEN CO.
MADE IN U. S. A.

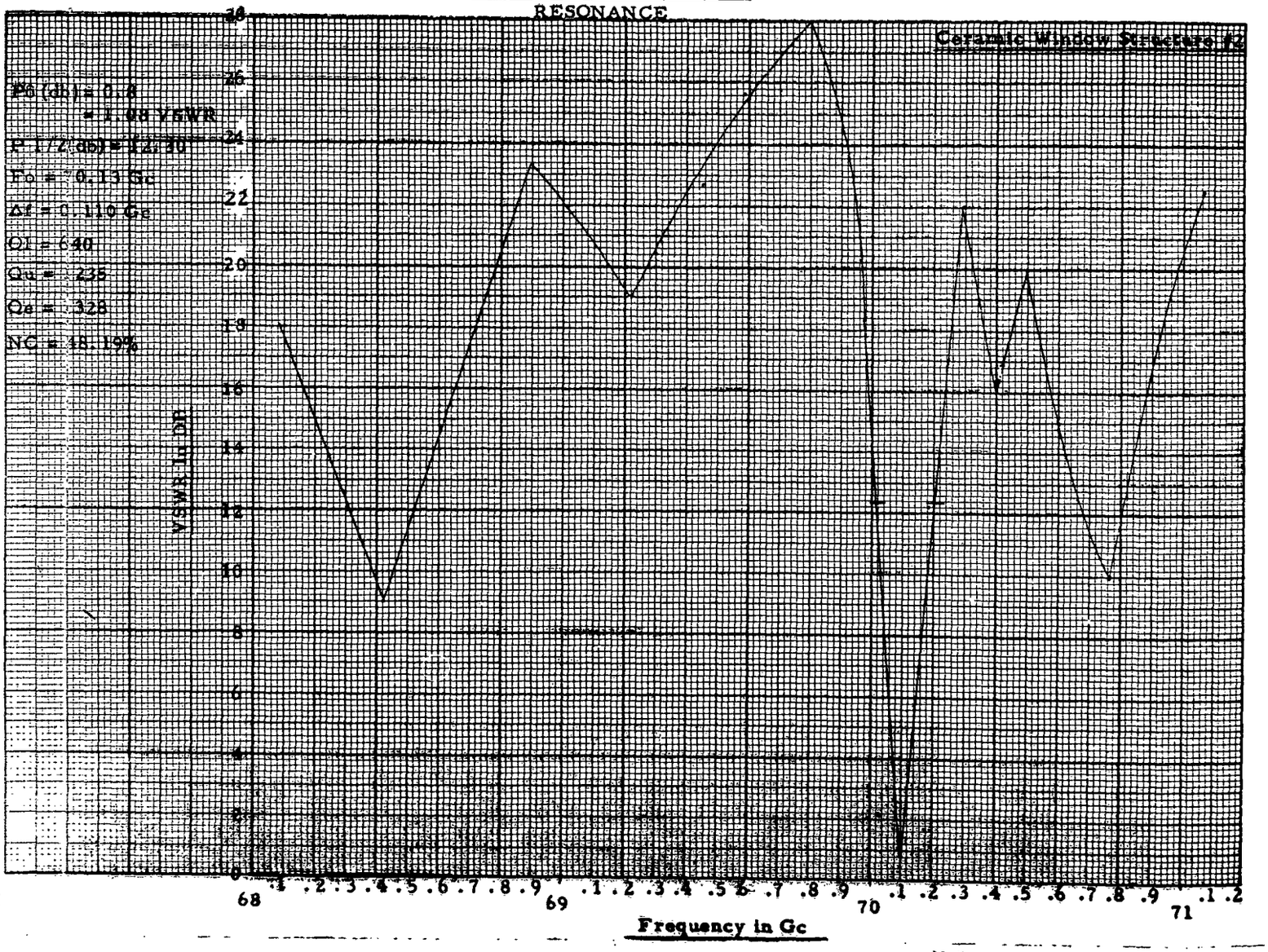
FREQUENCY vs VOLTAGE STANDING WAVE RATIOS FOR VARIOUS OUTPUT WINDOW STRUCTURES

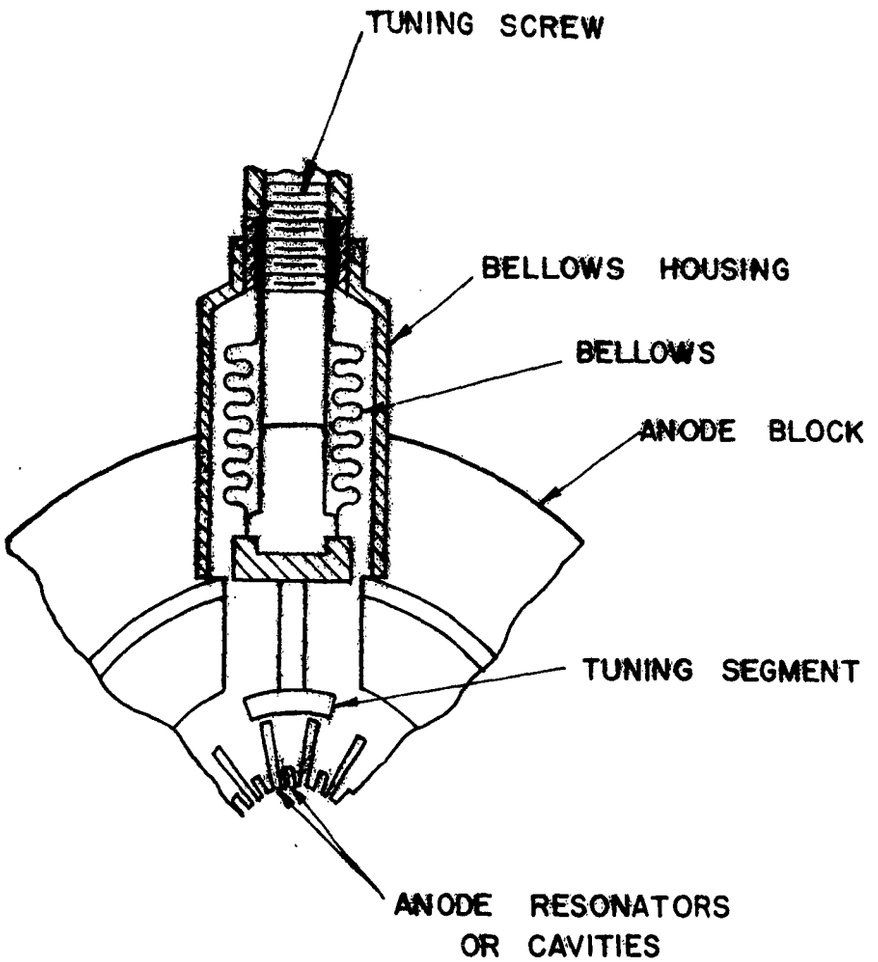


Frequency in Gc

COMPLETED TUBE (#4)

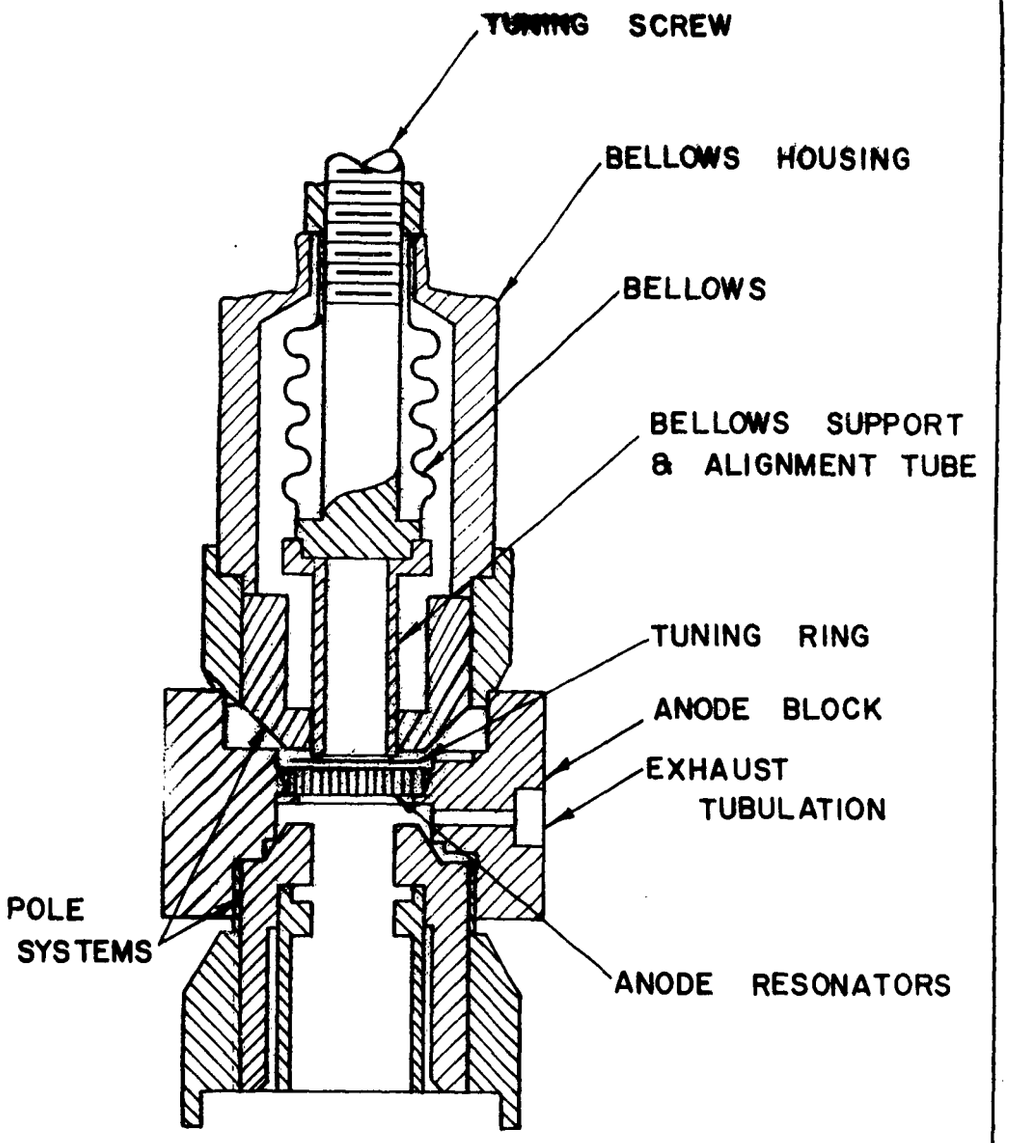
RESONANCE





	SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
	TUNER MODEL NO. 1	

W-101



	SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
	TUNER MODEL NO. 2	

W-101